Breeding New Vegetable Varieties

This is the Market Midget Watermelon, a variety with a tough rind which will not break when fruits are shipped to market. An improvement over New Hampshire Midget, this melon stores in edible condition for several weeks.

By Albert F. Yeager and Elwyn M. Meader

Station Bulletin 440 June 1957

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF NEW HAMPSHIRE
DURHAM, NEW HAMPSHIRE

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By Albert F. Yeager and Elwyn M. Meader*

THIS bulletin presents the breeding work with vegetables which has been accomplished since publication in 1950 of New Hampshire Agricultural Experiment Station Bulletin 380, "Breeding Improved Horticultural Plants — 1. Vegetables." Although it requires years of painstaking effort to originate and test a superior new vegetable variety, much faster progress can be made with vegetable crops than with fruits, such as the apple, for example, which may require ten years to fruit from seed.

Many persons have contributed during the past years to the success of this vegetable breeding program which, like any worthwhile scientific endeavor, depends upon the cooperation of capable individuals both within the Agricultural Experiment Station and elsewhere. Where such individuals have made major contributions, they have been mentioned directly in the text or by a conspicuous footnote to call attention to the work that they have done. As a matter of convenience in caring for the details of maintaining seed stocks and records, the senior author has taken the lead in tomato improvement, breeding for processing squashes, greenpod snapbeans, and beet and carrot work. The junior author has cared particularly for the work with honeydew-type melons, golden-rind watermelons, small individual squashes, peppers, eggplant, purple-pod peas, blue beans, pole beans, and horticultural beans. A close cooperation and a full exchange of ideas has made possible the vegetable breeding work. It seems best to credit worthwhile results to team work without which the breeding work would have been much curtailed. Not all who contributed to the vegetable breeding project can be mentioned. Anyone who has furnished seed for breeding or has made yield and quality comparisons can be truthfully said to have had a part in originating these new varieties.

A common question is: How are the new varieties made available to the public? Briefly, the several steps are as follows: First, when a new true-breeding vegetable selection seems to have merit beyond the tried-and-proven older sorts, seeds of the new variety, usually under an assigned number for trial purposes, are sent to certain qualified individuals within this and nearby states who can ascertain the desirability of the new kind as compared with the standard varieties they are growing. Trial seeds are sent also to other Agricultural Experiment Stations not only in this country but to those anywhere in the world upon a request from a qualified official. Commercial seed companies also ask for and receive seeds for their trial grounds. After a period of testing, any variety deemed worthy of introduction is officially named with the approval of the Director of the Agricultural Experiment Station. Seed of the newly-named variety is increased and handled by commercial seedsmen from whom it can be purchased by the general public.

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At all times, information is continually being made public regarding sources of supply for seeds of the new varieties.

The Agricultural Experiment Station does not produce seeds of the new varieties beyond what is needed to introduce the variety to the seed trade.

Greencrop Bean

As stated in Station Bulletin 330, one objective in bean breeding has been the development of a good productive variety of green snapbean having

The 1957 All-America Greencrop bean—a very large, podded, flat, white-seed bush variety adapted to home gardens, some local markets, and for processing.

white seeds. When a variety with colored seeds is processed in a glass container at the customary 15 pounds steam pressure for an hour, the cooked product shows up with a darkened appearance. This undesirable discoloration does not result when green snapbeans having white seeds are canned and cooked in a like manner. An improved green-pod snapbean with white seeds was desired particularly for the manufacture of baby foods that are packed in glass which allows the contents to show within the jar.

The first step toward origination of the desired new variety was the crossing of Bountiful and Streamliner. The latter has white seeds. Selec-

tions from this breeding were crossed with a red-seed variety from Australia which had long pods that were not genetically stringless. In the meantime, a machine suitable for harvesting snapbeans had been developed elsewhere. For the most efficient harvesting of snapbeans by machine, a variety was needed which matured at one time a large proportion of choice sizes of pods held well up from the ground on strong-growing upright plants.

Attention was given to these points in making the selections so that the new variety might be adapted to machine harvesting. When selections were ready for testing, the Beechnut Packing Company*, Canajoharie, New York, which manufactures baby foods, grew a crop of the several lines of selected snapbeans and processed them in their pilot plant. This aided in the selection of a line having low fiber content and excellent cooking quality. In field trials, the selected line NH #23 attracted attention as a desirable one for the fresh produce market. Further testing of NH #23 snapbean resulted in its being chosen as an All-American selection for release in 1957.

This photograph of the Greencrop bean shows the large number of beans which mature at one time, thus making this variety adapted to machine harvesting.

The name Greencrop has been assigned to the new variety. It is characterized by a strong, upright, bush plant bearing stringless, long, green, flat pods and white seeds. Greencrop has value for processing, for the fresh produce markets, for roadside stands, and for the home garden where a large pod green snapbean may be appreciated. Greencrop can replace the older Bountiful variety.

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* Beechnut Packing Company (now Beechnut-Lifesaver) contributed funds to aid in support of the bean breeding project.

Royalty Bean

This variety is a round-pod, bush, snap bean which resulted from a cross between Florida #501 blue pod, a climbing round pod variety, and a stringy flat-pod, blue, bush bean, an heirloom variety grown only by a few home gardeners in New Hampshire. In Royalty, the best characteristics of both varieties have been combined, giving a medium length, round pod, stringless bush bean of great productivity. The tan-colored seeds have marked ability to germinate in cold ground. Tan seed and blue-pod color, also called purple hull, seem to be closely linked. Thus far, all seedlings with blue pods also have tan seed. The plants have attractive purple flowers. Royalty is a useful novelty in that the pods contrast with the green foliage, hence, are easily picked. As soon as the blue pods have cooked in boiling water for one or two minutes they turn green. Thus for the home gardener who freezes beans there is the convenience of a built-in blanching indicator. The cooked beans are an attractive dark green; the flavor and quality are good.

The crossing of common beans is a difficult and tedious procedure, but selection in subsequent generations is easy because little natural crossing occurs. Beans are also easy to handle in the greenhouse. Many times we grow one crop in the field and three successive crops in the greenhouse during the winter months. Two calendar years of such intensive breeding may, and often does, result in a true breeding line.

Pole Wax Beans

A heavy producing wax pole bean. It is stringless, has white seeds, long pods.

There has never been a pole wax bean equal to the green-pod Kentucky Wonder. We therefore made a cross between a stringless, bush wax bean of our own breeding, having a low fiber content, and Kentucky Wonder. Continued selections were made from this cross for a vigorous productive climbing plant with stringless, large, straight pods and white seeds. The result is a productive wax, pole variety with pods up to a foot in length which have a better shape than those of Kentucky Wonder. A dominant gene for the stringless character has made this project difficult to complete. Seed of a desirable strain is now being increased.

Flat Seed Horticultural Beans

The lima bean, *Phaseolus lunatus*, is not grown generally in New Hampshire. A pole bean, with large flat seeds called Horticultural Lima, is grown

sometimes in New England. This name is a misnomer since it is properly classified among the common beans *P. vulgaris*. It seemed desirable to have a large, flat-seed horticultural bean useful for green shell and dry beans that would be borne on a bush plant. Crosses of Horticultural Lima were made with Bumblebee, a local variety having large, plump, white seeds with a soldier-like pattern about the eye.

From this cross, breeding lines having bush plants that yield large, flat seeds of three distinctive color patterns have been purified, namely: (1) solid light red; (2) red mottled; (3) light background with dark yellow streaks. These lines seem rather susceptible to bean mosaic and damage by leaf hoppers. At best, they are novelties and unlikely to be commercially important.

New Hampshire Giant Bean

In the process of developing the Greencrop snapbean, a selection having flat, green, stringless pods that grew 10 to 11 inches long and still maintained good edible quality was distributed for trial under the name New Hampshire Giant. After further testing, it was learned that production of seed of this variety was a problem in the eastern states. The large pods are attractive and of good quality and one of the seed companies in a western state has been able to increase the seed and catalogue the variety. While New Hampshire Giant is a fine snapbean, Greencrop can be grown in most sections of the country and it seems well adapted. New Hampshire Giant may be the largest podded, stringless, green, bush bean having white seeds that is available in the seed trade. Its greatest appeal is to home gardeners.

Horticultural Beans

Horticultural beans are an important commercial vegetable crop in New England and they are also a favorite food grown by the home gardener. The pods of some varieties may be used while immature for snapbeans, but this use has been superseded mostly by improved snapbean varieties. For the most part, the crop is harvested at the green shell stage of maturity when the pods of the common commercial variety, French Horticultural, and similar sorts are prettily splashed with bright carmine red against a yellow background color. The pods go to market in bushel boxes. The consumer shells out the beans by hand only to find that the attractive colors are a feature of the pod and the seeds are white with occasionally a few faint streaks of red. When the pods become fully mature, the dry seeds may be harvested for use as baking beans and several varieties of the horticultural beans are favored for this particular use.

Twenty years ago breeding work to develop new varieties of bush horticultural beans that had red-seed color, as well as attractive red pods, was undertaken and the varieties, Flash and Brilliant, described in Station Bulletin 330, were introduced. Both varieties have improved seed color. Flash is a bush plant, while Brilliant has trailing vines like French Horticultural. Newer, better ones are described in the following paragraphs.

Shelleasy

The testing of local heirloom beans resulted in selection of the Littleton, an early-maturing prolific kind with light-colored mottled pods, and large kidney seeds, having a light buff color with streaks of red. Crosses were made between Flash and Littleton and in due time gave rise to the Shelleasy named in 1951. This early bush variety proved more productive than

Four varieties of horticultural beans. From left to right: Scarlet Beauty, French Horticultural (an old commercial variety), Red Shellout, Shelleasy.

Flash. Shelleasy averages 5 to 6 seeds per pod and the percentage shellout of green shell beans measured repeatedly as 55 percent has been consistently the highest of all varieties tested at Durham. The pods have good outside red color in northern areas with cool summers, but they may become somewhat faded under conditions where high temperatures prevail. The variety was named Shelleasy since the pods at the green-shell stage of maturity may be opened readily by just a slight twist. This ease of shelling has been much appreciated by those who shell the beans by hand. Also Shelleasy has proved to be adapted to shelling by a machine, such as the rotary-cylinder type of pea huller.

Scarlet Beauty

At the same time crosses were made between Littleton and Flash, crosses were made also between Flash and another local variety called Pittsfield, a pole variety with large pods. This latter cross led to the Scarlet Beauty which was released in 1953. This kind has large seeds with dark red streaks of mottling on a pinkish red background color. The green shell beans of Scarlet Beauty are virtually as bright as a ripe cranberry. Moreover, the attractive red color is retained to a large degree in cooking; all other varieties of green shell beans turn a light brown color when cooked. The large upright bush plants of Scarlet Beauty, while productive under ideal conditions, are rather susceptible to common bean mosaic and leaf-hopper damage. Scarlet Beauty can also be shelled satisfactorily by machine.

Red Shellout

Over a decade ago crosses were made between Flash and the White Runner bean, *Phaseolus multiflorus*. The interspecific hybrid had bright scarlet flowers similar to the Scarlet Runner bean. During germination, the cotyledons of Flash, similar to all common beans, come above the soil. Contrastingly, seeds of the runner beans remain below the ground much like a garden pea. Cotyledons of the hybrid plants came just to the soil surface. However, the hybrids proved self-unfruitful in the greenhouse. Resort was made to cuttings of the tall climbing hybrids. Many cuttings rooted readily when placed in bottles of water. Potted rooted cuttings were transplanted to a field where horticultural beans grew nearby. Bumblebees visited the red flowers of the hybrid bean plants, as well as the flowers of the other beans, and as a result sufficient mature seeds were obtained from the hybrids to make possible a second generation. It is presumed that the seeds came mostly from backcrossing with the common bean, though it has been possible to secure backcrosses to the runner beans as well. Selection in the third generation and through subsequent generations was for fertile plants having the dominant red flower characteristic.

Finally after 15 or 16 generations of plants had been grown, some in the field and others in the greenhouse, it was possible to get true-breeding lines having certain desired plant characteristics. A particularly productive line, with red seed color similar to Scarlet Beauty, has light red flowers which not only beautify the plants but aid in their identification. This new bush variety has been named Red Shellout. It was so named because it is anticipated that its fullest usefulness may be realized when the beans are offered for sale shelled from the pods. The shelled beans are put into quart berry baskets for display in certain local markets.

It is anticipated that Red Shellout, or a similar type, may eventually find use for commercial canning of shell beans packed in glass containers since the cooked seeds retain their attractive reddish color. All other varieties, except Scarlet Beauty, cook an appetizing brownish color somewhat like baked beans. The dry beans of Red Shellout when baked also retain some of their red color, have a pleasant grainy texture, and have been rated excellent in flavor.

Sweetheart Beet

In 1949, a sugar beet, U. S. #225, that had been received from Dr. G. H. Coons, United States Department of Agriculture, Beltsville, Maryland, was included among varieties of table beets grown in variety trials at Durham, New Hampshire. Samples of the several varieties were canned* and taste-tested later by a panel of judges. The interesting fact was learned that most people preferred the canned sugar beet to all others except for its white color. Hence it was decided to originate a red table beet having the sweetness of the sugar beet.

Roots of U. S. #225 sugar beet and Detroit Dark Red table beet were forced in the greenhouse and when they began to flower were placed in close proximity. Merely by tapping the stems of the plants, clouds of the

* Miss Frances Platts, Home Economics Department, cooperated by preparing canned samples of the beet varieties.

light pollen were readily carried by the slightest air currents from flowers of one plant to those of another plant. Seeds from the sugar beet were saved and planted in the open field. As the white root color is recessive, all those seedlings showing red color indicated hybridity. These hybrid beets, after having been held in cold storage, were brought into flower in the greenhouse under lights used to supplement the short photoperiod during the winter. Seed was saved for a second generation which was grown in the field. Those beets of good shape and having solid red color throughout the root and a high sugar or total soluble-solids content were selected for seed production. The internal root color was determined by pushing a one-quarter-inch cork borer through the side of the beet. The presence or absence of white zones of color within roots that had a solid dark red exterior could thus be readily observed from the small cylinder of flesh removed, yet with only slight damage to the root.

Sweetheart beet—a late table variety, much sweeter than other table kinds.

The relative sweetness of roots was measured by use of a Spencer Standard Abbé-type refractometer. A small piece gouged from the side of a root was squeezed between the jaws of a pair of hand pliers until a drop of juice flowed on to the slide of the refractometer. Thus a reading for the total soluble solids of each root could be made rather quickly. Only those red roots having a reading similar to the sugar beet were saved for seed production. Again seed from these selected roots was harvested in the greenhouse during the winter. The seed from each plant was kept separate to allow for progeny testing in the field the next summer. From the best progeny lines further selections were made and the procedures as already outlined were repeated until true breeding lines had been established. As a result, a new late variety of red table beet, having smooth, oval, tapered roots with a total soluble solids reading of 15 percent, has been named Sweetheart. This reading, which approaches the value for a sugar beet, is largely due to the presence of sugar. Most varieties of table beets have readings of only 7 to 10 percent solids. Sweetheart beet has been rated excellent in cooking tests and it has merited only praise from those home gardeners who have grown this new table beet. The roots store exceptionally well. Sweet pickled beets may be prepared by the use of vinegar only as no additional sugar is needed with the new Sweetheart variety.

Other Beet Breeding

Sweetheart has now been crossed with an otherwise unpurified but monogerm beet which has only one seed in a pod. The object is a quality table beet which can be grown without thinning the plants.

Red Brussels Sprouts

Catskill, an early-maturing, dwarf, green variety, is the only Brussels Sprouts which produces a worthwhile crop at Durham, New Hampshire. In variety trials a tall-growing European variety having attractive bright red color proved too late to be satisfactory, although it might produce a good crop where the season is longer. A cross was made between the dwarf green Catskill and the tall red variety within the greenhouse during the winter of 1954-55 in an attempt to produce an early dwarf variety with red sprouts. The first generation plants, when grown in the open field in 1955, were tall-growing and an intermediate red color. Some of the best of these were sib-pollinated in the greenhouse during the following winter and a second generation was grown in the open field in 1956. Seeds were sown directly with 5 to 7 seeds being dropped in a place. As soon as the plants had grown several inches tall, all green seedlings were removed. Later each hill was thinned to a single individual plant which showed the most red pigment. Thus over 4,000 plants were observed in the second generation, not one of which had the combination of dwarf plant with a dark red color fully equal to the red variety used in the cross. Some choice dwarf plants with intermediate red colored sprouts have been sib-pollinated and also backcrossed to the red parent to enable selection of the desired dwarf red plants in following generations. That a good dwarf red variety of Brussels Sprouts can be produced seems assured from the progress already made.

Red Chinese Cabbage

Though both are called cabbage, actually Chinese Cabbage, *Brassica pekinensis*, and common cabbage, *B. oleracea* var. *capitata*, are two distinct species. Natural crosses between the two species are rare. Nevertheless, as early as 1942 it was learned that crosses were possible when the Chinese Cabbage was the female parent. Many varieties of Chinese Cabbage are grown in oriental countries, but so far as we know there is no red Chinese Cabbage. In 1947 Wong Bok Chinese Cabbage was pollinated with pollen from a selected red common cabbage. No attempt to emasculate flowers was made. The red color is dominant and any hybrid seedling can be distinguished readily by the presence of red color. Such hybrid seedlings proved rather sterile. This lack of fertility may be associated with the assumed chromosome number of the hybrid (2n-19), though no count was actually made. This number is intermediate between the parent species: Chinese Cabbage (2n-20) and common cabbage (2n-18). The hybrids are strong-growing, leafy plants tinged with red color and resemble a non-heading type of Chinese Cabbage. Vegetative cuttings were made from short portions of the leafy, flowering stalks of the hybrid plants. This type

of cutting rooted readily and gave additional numbers of the hybrid plants. some of which were treated with colchicine. It was hoped that a doubled number of chromosomes might influence favorably the apparent lack of fertility in the hybrids. Several colchicine-treated plants had extra large flowers, large stomata. large pollen. and a greatly increased number of chromosomes, presumably 38.

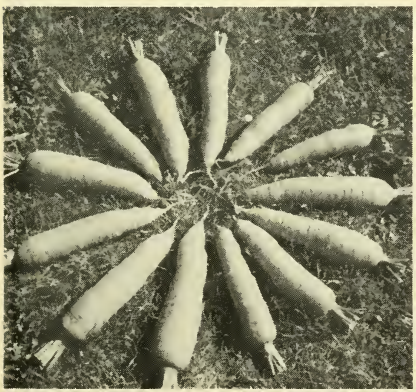
By repeated vegetative propagation. a stock of these hybrids with the large flowers was maintained for several years. In all. about sixty plants were grown in the field from the few seeds that could be obtained from the C-treated hybrids. None of the F_2 plants appeared promising. though they were markedly variable. Again no seed was obtained from these second-generation plants due both to sterility and their late flowering in the field. Insects were observed visiting the flowering plants which should have insured adequate pollination.

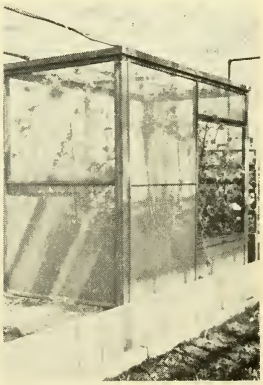
The rutabaga. *Brassica capestris* var. *napobrassica*. belongs to the cabbage family and has either 36 or 38 chromosomes depending on the particular variety. This count is approximately twice that of the Chinese x Red Cabbage hybrid. Hence, it seemed feasible to try crosses between the large-flowered colchcine-treated cabbage hybrids and the rutabaga. Reciprocal crosses between a yellow-fleshed rutabaga (variety not recorded) and the large-flowered cabbage hybrids were made without difficulty. Ample seeds for hundreds of plants in the next generation were obtained. Thus it was possible to select either leafy-type vegetables or a root crop from among the variable population of plants grown from the seeds of a complex ancestry.

The following discussion will deal with selections directed toward origination of a red Chinese cabbage. Many plants of the complex hybrids, achieved by crossing of the three *Brassica* species. were loose-leaf types varying in their respective amounts of red and green pigment. but few showed any promising tendency toward a desired firm-heading. red Chinese cabbage. Production of seed from any selected plants became a problem. Seemingly. indifferent progress was being made. So selected plants of the large-flowered Chinese x cabbage hybrids crossed with rutabaga were backcrossed with Chinese cabbage. Results from this approach were somewhat encouraging. and it might have been continued had not further work proved that the vegetatively propagated plants of the original colchicine-treated Chinese x red cabbage, when used as female parent. could be backcrossed successfully also with Chinese cabbage. Size of flowers varied from plant to plant among these vegetative propagations. Whether some may have been diploid and others tetraploid cannot be told as no counts of chromosomes were made at that time. Regardless. this backcrossing to Chinese cabbage has now progressed through second backcrosses. Continued selection has been made for those young seedlings in a seed flat that showed red stems soon after germination. Only such colored seedlings were carried along for further seed production. In the field in 1956. plants that had a firm head similar to the tall slender varieties of Chinese cabbage and which had some red color in their outside leaves were saved for seed production. These selected plants have been sib-pollinated in the greenhouse to learn whether some of them may be carrying factors for intensification of the red color. Certainly, factors for red color originally in the common cabbage have been transferred by backcrossing into the Chinese cabbage. Further work is needed to produce a satisfactory red Chinese cabbage for commercial use.

Durham Carrot

The Hutchinson variety of carrot is popular with market gardeners in New England because of its vigorous plants with attractive roots. Its table quality, however, is disappointing. A cross was made, therefore, between Hutchinson and Morse's Bunching, a kind similar to the high quality Nantes variety. It was planned to select from this cross a variety having roots of long attractive shape and high table quality. The carrot has a composite flower consisting of many small florets. Manipulation of such small flowers by hand methods in controlled breeding work is difficult, though copious crops of carrot seed result in the open field as a result of insect visitations of the flowers. Hence, resort was made to insects for pollination of flowers of carrots forced into bloom within the greenhouse during the winter. Several plants of the two varieties to be crossed were enclosed within a screened cage and houseflies* were released in the cage for a pollinating agent. The seeds from each plant were saved separately. When each lot of seed was grown in a single row in the field as a progeny test, the F_1-hybrid plants could be distinguished by their exceptional vigor and certain dominant characteristics. Seed of the F_1-plants was raised in the greenhouse during the winter. The procedure for this has already been described. Thus a second generation could be grown in the field the following summer. Carrots of the desired size, shape, and rich orange color inside the root were selected from the variable second generation. Each carrot was cut to expose a cross section of the interior of the root before a final selection was made for seed production. Usually eight or ten such selected carrots were allowed to mass pollinate within a single cage. This has helped to maintain vigorous lines of carrots down through the several generations necessary to establish the new variety now called Durham Carrot.





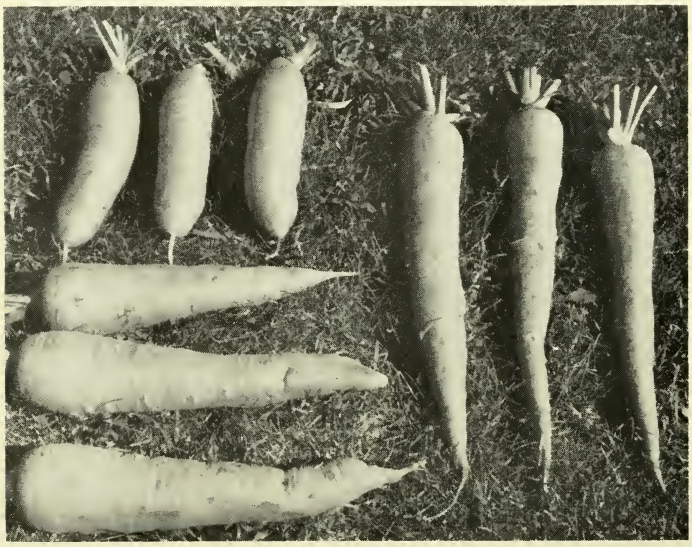
The Durham carrot (at left) is a medium long, high-quality variety which is adapted to bunching or packaging. At the right is the cage in the greenhouse where the carrots are grown for seed. Pollination is provided by house flies.

* The Entomology Department rears houseflies for use in testing the effectiveness of insecticides. Repeatedly, the entomologists have furnished flies for pollination of vegetables.

Since this breeding project was started, a notable change in the marketing of carrots has taken place. Carrots no longer go to market in bunches with the tops tied together. Long slender roots, with all tops carefully trimmed off, are neatly pre-packaged in polyethylene transparent bags of convenient size for the consumer. Thus the emphasis on carrot breeding has changed and further work with this root vegetable is discussed in the following paragraphs.

Bitter-free Carrots

There have been complaints in recent years about a bitterness in carrots, which develops in intensity during storage of the roots. Large numbers of stored carrots have been examined and tasted and an occasional root has been found that was free of this bitter flavor. It was hoped that these good carrots might not develop any bitterness because of a favorable inheritance. Large numbers of carrots of the red-cored Chantenay variety were taste-tested and also assayed by chemical means.* The selected carrots were planted in the greenhouse and brought into bloom within screened cages. House flies, which carry the pollen from one plant to another, were released in the cages. Thus carrot seed of selected plants was produced and planted in the field in 1954. The crop grown was put in a storage where



This is the beginning of a carrot-breeding project. Upper left is the Nantes. At the right is a high-color Japanese carrot. At the lower left is the F_1 hybrid.

* Dr. Warren Averill, Department of Agricultural and Biological Chemistry, has cooperated most capably in the chemical analyses.

apples were also kept, and again those which failed to develop bitterness were selected for seed production. Seed from these selected carrots was planted in the field during 1956. The 1956 crop from storage has been sampled once more and the development of the bitter principle has been only $\frac{1}{4}$ that of the standard red-cored Chantenay. Seed is being grown again from carrots selected for their good flavor. Eventually a strain may be produced which will not become bitter in storage.

Other Carrot Breeding

At the present time, there seems to be a preference by consumers for a long slender carrot of good table quality. The ideal type might be a cylinderical root, or nearly so, about eight inches long with bright orange outside color and with crisp, sweet flesh that rates excellent flavor when cooked. Crispness and fine table quality are found in the Nantes variety. A carrot from Japan grown in the variety trials was found to have very long slender bright orange roots. This oriental carrot also had strong vigorous tops. All of the desired characteristics for an ideal new variety seemed to be found in these two varieties, so crosses have been made between them. Even after fully utilizing the greenhouse facilities and the techniques for carrot breeding as already outlined, it will still be several years before this project can be completed.

Cocheco Sweet Corn

In 1947, a cross was made between the extra early, yellow, sweet corn variety, Golden Gem, and a flint corn, Fort Kent by name. This field corn from the Maritime Provinces of Canada is extremely early. The objective of the cross was to produce a sweet corn fully as early as the Fort Kent corn. The resulting variety, Cocheco, is earlier than any other sweet corn we have grown at Durham, New Hampshire, is yellow in color, but has only fair table quality. Cocheco has short stalks; in fact, such short stalks that the ears are sometimes picked at by crows standing on the ground. The ears have mostly eight to ten rows of kernels. Cocheco has merit for its extreme earliness as a yellow sweet corn. It should be of use to plant breeders who want these characteristics as a starting point for producing an early variety for the commercial gardeners. Cocheco can be grown by home gardeners where other varieties are too late to mature.

Eggplant Breeding

The New Hampshire eggplant described in Station Bulletin 330 is a popular early, large, black variety for northern states. Only one other kind has been earlier than the New Hampshire eggplant at Durham, New Hampshire. It is a variety with tomato-shaped, green-striped, immature fruits that ripen a brilliant scarlet red color. This variety is called Chinese Red or Oriental Scarlet. It belongs, however, to the species, *Solanum integrifolium*, which finds use primarily as an ornamental plant in this country.

Reciprocal crosses were made between the Chinese Red and New Hampshire eggplants in an attempt to get an extremely early variety from this

inter-specific cross. It was hoped that a large-fruit. red eggplant might also be obtained. The first-generation hybrid plants proved unfruitful both in the greenhouse and open field. Self-pollinated flowers on plants in the greenhouse failed to set fruits. Nevertheless, backcrosses to both parents were successfully made in the greenhouse though many of the red-ripe fruits were parthenocarpic. Fruits devoid of seeds also occurred in the field. In the greenhouse, only six plump seeds were obtained from twelve fruits resulting from a backcross to New Hampshire. Ordinarily a single eggplant fruit will have hundreds of seeds. When the first-generation hybrid was backcrossed to the Chinese Red eggplant, a total of 65 seeds was realized from many fruits saved in the greenhouse.

Some first-generation plants (New Hampshire x Chinese Red) and (Morden x Chinese Red) were treated with colchicine by Mr. Stanley Berry* to see if lines of tetraploid plants might be more fertile than the self-unfruitful diploids. Two fruits, two and one half by two inches in diameter and much larger than any parthenocarpic fruits, occurred on a branch of an F_1-plant of Morden x Chinese Red, a plant that had been treated with colchicine. These two fruits gave 110 rather large seeds.

Plants for the next generation, both of the backcrosses and the colchicine-treated lot, proved interesting when grown in the field. However, the latter proved so late in maturity and relatively infertile that only one line has been maintained — and with difficulty — up to the present time. It has red, oval fruits borne in clusters and up to 3 inches in diameter.

Some fruitful plants occurred in the first backcross generation and five early selections were made for use in continued breeding. This has taken the approach of further backcrosses and mating of selected plants.

It became apparent that open-pollinated plants in the field had been out-crossed rather frequently instead of self-pollinated. So a regular procedure was used of making single-plant selections in the field in the fall to be taken into the greenhouse during the winter for self-pollination. An unexpected result has been the appearance of many spiny plants in subsequent generations though both parents of the cross are unarmed. This has caused the discarding of many plants.

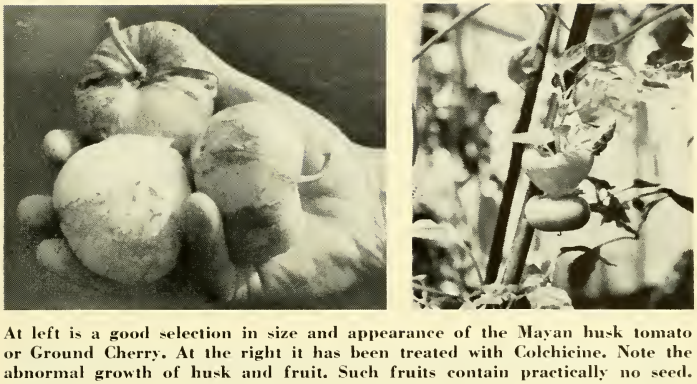
Breeding work has proceeded now through three backcrosses with continued selection of selfed plants. Several lines of early, large, dark-fruited eggplant that set somewhat in clusters are at hand, and also some of a large green-fruited line that have mature yellow fruits instead of the desired red color.

This has proved to be a difficult breeding project because of self-sterility of the interspecific cross, and failure of many plants in following generations to mature even one fruit.

Ground Cherry Breeding

The ground cherry, also called husk tomato and termed Cape Gooseberry in England and South Africa, is an important commercial crop used for preserves or jam in those countries. The species of ground cherry of importance in the old world countries is *Physalis peruviana*. In the United States, two other species are used for garden crops to a rather limited extent. The common ground cherry, *P. barbadensis*, produces yellow berries

* Graduate Assistant in Horticulture. 1952-53.



At left is a good selection in size and appearance of the Mayan husk tomato or Ground Cherry. At the right it has been treated with Colchicine. Note the abnormal growth of husk and fruit. Such fruits contain practically no seed.

about $^3/_8$-inch in diameter within balloon-like husks. These berries make excellent preserves. The second species, *P. ixocarpa* or Mayan ground cherry, was introduced into this country from Central America and Mexico. It has large, light greenish or yellow, tomato-like fruits two inches or more in diameter that fill or burst open their surrounding husk. In the countries to the south of the United States, the large ground cherries are used much as the tomato is eaten in this country. Despite the subtropical origin of the Mayan ground cherry, it is remarkably early. The fruits will ripen in areas too far north for successful culture of the earliest tomatoes.

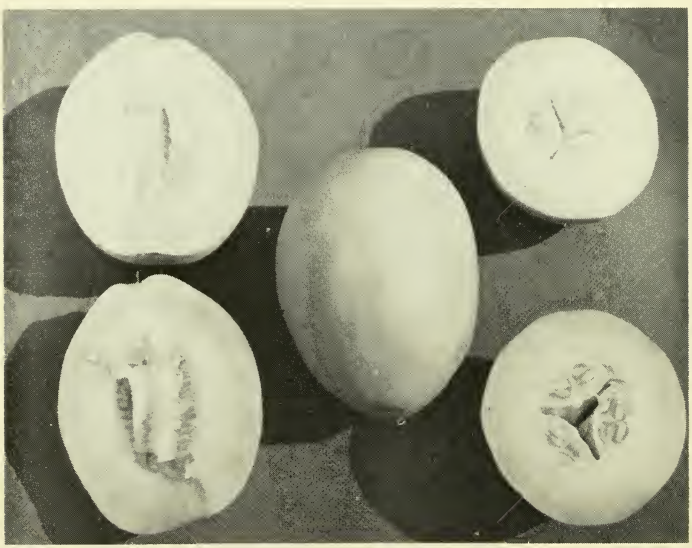
Within the several species of the ground cherry noted there are available all necessary characteristics for an extremely early new vegetable plant bearing appetizing attractive fruits of good size and flavor, if only the desired crosses can be accomplished. Crosses have been tried repeatedly in an attempt to combine the size and productivity of *Physalis ixocarpa* with the good-flavored fruits of either the common ground cherry or the Cape Gooseberry. Mr. Shi-an Yu* succeeded in getting some seeds from attempted interspecific crosses, but the F_1 plants grown in the field in 1956 proved mostly sterile. Frequently only parthenocarpic fruits are obtained following interspecific pollinations. Colchicine treatment of plants has also been tried without appreciable gains. The greatest progress to date has been by selection with the somewhat variable populations of the Mayan ground cherry; also some superior selections have been made from the common ground cherry. Observations on several other wild species of *Physalis* are being made and further breeding work with the ground cherries is contemplated.

Nectarmelon

In Station Bulletin 380 mention was made of crossing a Korean sweet melon and Granite State muskmelon. Even more promising results have been procured from a cross betwen the Korean sweet melon, Kimmaka, and a honeydew melon from North Africa called Jauné Canaire. The latter cross

*Graduate research assistant 1954 to present.

made possible selection of an extremely early-ripening, green-fleshed melon somewhat like a honeydew. The ripe melons have smooth golden rind and weigh about one pound. They mature ten days before the Granite State Muskmelon. The new melon has been named Nectarmelon. While having some of the flavor of a honeydew, it is quite distinct from an ordinary honeydew. When ripe the fruit separates from the stem like a muskmelon rather than remaining attached to the stem as does the honeydew. Both in New Hampshire and other northern states, Nectarmelon has been the first variety of all to ripen. The early ripening habit may be associated with relatively poor production of viable seeds, particularly during a cool summer in northern states such as occurred in 1956. A poor season for seed production has delayed increase of the Nectarmelon for release by the seed trade. Because of its extreme earliness and convenient small size, Nectaremelon should appeal particularly to home gardeners in the north who have difficulty in ripening melons.



Nectarmelon, a honeydew type which will mature in very short growing seasons.

Other Muskmelon Breeding

While the Nectarmelon is a satisfactory and desirable fruit, a larger melon of the honeydew type would be better for market. No variety of the honeydew is sufficiently early to mature most years in the northeastern states from seeds planted directly in the field. Nectarmelon was, therefore, backcrossed with Jauné Canaire. Third generation plants have been grown in the field and some fine high quality honeydew melons up to six pounds in

weight have been selected. Both melons that slip from the stem when ripe and those that have a stem attached like a honeydew can be selected. Final selections must await the growing of several generations to insure true-breeding lines, but the expectation is for an early-maturing honeydew fully satisfactory for commercial marketing.

Because of the extreme earliness and high quality of Nectarmelon, it has been used in other crosses with muskmelons in an attempt to produce early-ripening varieties. Nectarmelon has been crossed with Bay City Pumpkin muskmelon, an early, large, oblate, ribbed variety grown somewhat in Michigan. It has also been crossed with Delicious 51. Both muskmelons have salmon or orange flesh. Likewise, third generation plants from these crosses have been fruited with some high-quality, netted melons secured ripened earlier than the Granite State variety. Of much interest were some large, netted melons with nearly white sweet flesh. Not only green- and orange-fleshed melons appeared in the breeding lines, but occasionally there was a single melon having various combinations of the two colors in the flesh. Whether a new variety will be introduced from this series of crosses remains to be seen, although some rather promising melons have been grown.

Purple Pod Peas

Peas are a popular garden vegetable, but the picking of the pods is something of a chore. A chance remark of a housewife, that it would be nice if only the pods were red so that they would contrast with the green of the plants, led to this pea-breeding project. Shortly afterward, in a seed catalogue received from England, a variety of peas was noted which was listed as not being bothered by birds. Seed was procured. The variety was a tall-growing, wrinkled pea of fair table quality, but it had purple pods. The shelled-out peas were a light green color. A cross was made between this tall, purple-pod variety and several dwarf varieties of good table quality, namely Mayflower, Tiny Tim, and Progress No. 9. From these crosses, selections have been made for a dwarf, high-quality, purple-pod variety. The cross with Progress No. 9 has been particularly promising.

The purple pod character proved dominant. Thus in crosses between purple-pod and green-pod kinds, the first generation plants all had purple pods though not so deep a purple color as the purple-pod parent itself. Moreover, the flowers of the purple-pod parent and the F_1 plants also are reddish purple in color as well as there being some red pigment showing in the axil of the leaves where they join the stem of the plants. Thus, in the second generation, those plants having only green pigment in the leaf axils and white flowers, if left to blossom, were eliminated as it was known in advance that they would have green pods. It was noted that if a dwarf plant having deep purple-pod color in the F_2 was selected, that these selections for the most part came true for purple-pod color in the next generation, whereas a selection having a diluted purple-pod color usually segregated green pods in the following generation.

When a number of lines of dwarf, purple-pod peas had been purified, it was found that the intensity of purple-pod color varied in different strains. The desired purple-pod color in some lines faded badly as the pods neared the proper stage of maturity for harvesting. The kinds that fade have been

discarded. Following increase of the seed of the dwarf lines having non-fading pods, cooking tests were started. Some lines had peas that were unpalatable, being of a puckery nature. A chemical test revealed that the unpalatable peas had a high content of tannin, in itself not so much harmful as distasteful. So purple-pod peas were grown in the greenhouse under lights to supplement the short photoperiod during the winter, and the peas in a single pod taken, one pod from each plant, were cooked. Some plants were found that had peas of sweet flavor. Seed of these has been increased for field plantings. Also backcrosses of the dwarf purple-pod lines have been made to high quality, dwarf, green-pod varieties, to aid in the selection for additional table quality if this is found necessary after proving of the present promising lines. Seemingly, a dwarf purple-pod pea of good quality should become popular with home gardeners because of the convenience of harvest associated with a pod color that contrasts with the green of the plants.

Permagreen Pepper

Large green peppers of the California Wonder type are a popular market item. Sometimes green peppers held in the retail stores for several days begin to turn red, a natural result of ripening. This is undesirable as most consumers seem to prefer either fully green or fully red-ripe peppers. A most interesting pepper was received from Dr. Paul Smith, Davis, California. This pepper had a deep dark-green color while immature and also retained this green color when fully ripe. It was, however, late in maturity and the fruit was long and slender and had thin walls. In itself, this permanent green pepper had no commercial value. A cross was made between it and the early Merrimack Wonder pepper which is adapted to northern states. The fruits in the first generation were all red color when fully ripe. Since the permanent green color is a recessive character governed by two factors, only one in sixteen plants could be expected to have the desired dark-green, ripe fruits from among those plants grown for the second generation. Segregation for fruit color in the second generation as noted by Paul Smith is for 9 red, 3 brown, 3 yellow, 1 green.

From among the number of F_2 plants that we were able to grow both in the greenhouse and the open field, it was not possible to select a green, ripe pepper that had all desirable horticultural characteristics directly from this generation. By noting the relative degree of green pigment in the ovary at full bloom or a few days later and by selection of those plants having real dark-green ovaries, it has been possible to eliminate larger numbers of plants and yet save those few plants that would mature green-ripe peppers. The early maturing plants were chosen at full bloom by selecting the plants to open their flowers. Such selected plants were transplanted to the open field. A few days before frost, the most promising permanent green plants were dug, pruned back somewhat, all fruits removed, and then potted for removal to the greenhouse.

Growing of a crop of fruits within a screened greenhouse was necessary to avoid chance crosses from insect pollinations in the field. This procedure also enabled the making of backcrosses during the winter. One backcross was made to Merrimack Wonder and from those plants having permanent green ripe fruits in the ensuing segregating generation, several promising

selections were made. Several true-breeding lines have now been established that have green ripe fruits of a desirable size and good blocky shape, but the fruit wall is rather thin. For this reason a second backcross to Burlington, a large thick-walled, red, sweet pepper was made during the winter of 1956-57, and the selection for the ideal green ripe pepper will be continued in following generations. It seems that eventually the desired objective of a permanent green-ripe pepper having large fruits and early dependable crops can be realized.

Pinocchio Pepper

A cross was made between two pepper varieties obtained from Canada to obtain this new, early, dwarf plant that can serve as a dual purpose useful and ornamental pepper variety. The variety Early Sweet from Canada had sweet, early-ripening, red fruits. A single plant having upright or erect fruits at harvest was chosen for one parent. The other parent, Christmas Bell, had a dwarf plant with small, pointed, pungent, red fruits and had found use primarily in the greenhouse, being used as an ornamental plant, much as is done with the Jerusalem Cherry. From the cross, Early Sweet #1-48 x Christmas Bell, selections were made for a dwarfy, bushy plant producing all its bright-red, finger-like, sweet fruits over the top of the plant well above the leaves. Selections were made also for extreme early-ripening of fruits. The variety, Pinocchio, is the first variety of all to ripen its fruits at Durham, New Hampshire.

Visitors to the experimental plots have admired its cheerful appearance and some home gardeners have expressed the desire to use it for an ornamental border plant. As the plants grow only one foot tall, they can be spaced rather closely in the garden. Just before fall frosts, plants with their load of fruits can be transplanted into pots and taken into the house. After serving for decorative purposes, the rather thin-walled, red, ripe fruits can be dried readily without spoiling, if handled properly, and then ground up for use as paprika by the housewife.

Pinocchio pepper (left) is a sweet, edible, finger-like variety with fruits upright on a dwarf plant. It is primarily an ornamental. The Sweet Salad pepper (right) is tomato-shaped with thick walls and has sweet tender flesh. It is very early.

Sweet Salad Pepper

This early, tomato-shaped variety came from a cross of first generation hybrids of Merrimack Wonder and Pennwonder which had been pollinated in the greenhouse with pollen of the round, pungent variety, Large Red Cherry. This cross gave oval-shaped fruits which were hot in taste. Purified lines were selected for earliness, sweet thick-fleshed fruits with a cavity only sufficiently large to enclose the seeds, and an ability to set heavy crops of fruits. One such attractive breeding line of pepper was named Sweet Salad. It is the earliest, red, thick-walled, sweet pepper we have grown. It is of value in northern states where dry weather prevails during early September. After beginning to ripen, the red fruits may develop a moldy core during extended periods of rainy weather.

Other Pepper Breeding

As an interesting novelty, a very small sweet pepper is being perfected. This has gone through two stages, one crossing Pinocchio sweet pepper with a small, red-cherry variety and selecting from its descendants the smallest sweet peppers that could be procured. These have again been crossed with a very tiny, round, hot pepper and from this cross the second generation selections have been made. Some perfectly round tiny sweet ones have been procured. They are not yet at the naming stage. From the same cross, some extremely early-ripening, hot peppers have been selected. If there is enough demand for extremely-early, hot peppers, these may also be continued to purification.

Red Rutabagas

As stated in the discussion of Red Chinese cabbage, it became possible to select for a root crop from among the variable population of plants resulting from a complex ancestry of Chinese cabbage, red cabbage, and rutabaga. Those plants in the segregating generation having the most red pigment and which showed some tendency toward swollen roots were selected and taken into the greenhouse for forcing into bloom during the winter. These selected plants were inter-pollinated and some of them were backcrossed to a yellow-fleshed rutabaga. From the field-grown crop matured in the fall of 1952 and in ensuing generations, continued selection for those individual plants having good-shaped roots with superior red color was practiced without reference to whether the selected plants came from seeds resulting from the inter-pollinated or the backcrossed generations. Eight to twelve selected plants were inter-pollinated to give seeds for the next generation. With each succeeding generation, less variability in the amount of red color and root shapes could be discerned. Any plants so infertile as to not produce a seed crop were eliminated.

At harvest time in 1954, white-fleshed and yellow-fleshed roots were kept separate. Thus lines for yellow-fleshed rutabages having intensified external red color were found to be breeding true in 1955, while the white-fleshed

A high-quality, red rutabaga growing in a pot in the greenhouse for seed.

lines all continued to segregate for roots with yellow flesh. Cooking tests were made of both the white and yellow rutabagas grown in 1956. Critical judges evaluated the roots of several breeding lines, both white and yellow, for tender flesh of good flavor.

Seemingly, the bright red color of these rutabagas should add to their attractiveness for display in the retail markets or on roadside stands, particularly so when the roots have been waxed. Several of the breeding lines are exceptionally vigorous and produce round or heart-shaped roots eight to ten inches in diameter. Such large roots may be especially desirable for use where rutabagas are peeled, cubed, and prepackaged in polyethylene bags.

From the standpoint of genetics, it is of interest that the white-flesh color of the roots must have come from either the Chinese cabbage or the red cabbage as only true-breeding, yellow-fleshed rutabagas were used in the breeding work. Also the intensified red, external root color must have been derived in part from the red cabbage.

Orange Buttercup Squash

The Orange Buttercup squash—an early, crown-setting, high-quality variety.

An eight- to ten-pound squash, *Cucurbita maxima*, imported from Turkey by the Office of Foreign Seed and Plant Introduction under the name Balkabagi, was found to have excellent table quality. Both blue-grey and orange squash was inbred until purified for color, shape, and quality and then crossed with New Hampshire Bush Buttercup variety, previously described in Station Bulletin 380. It was desired to bring into combination for a new variety, early, modified, bush-type plants and orange fruits similar to the Buttercup in quality. After five generations of self-pollination of selections made in the second generation from this cross, a squash variety with bright orange color, rich orange flesh of high quality, and productive of fruits borne close in at the crown of the plant is available for testing further in northern states. The plants set one or two, four- to five-pound fruits within two feet of the base of the plant, and following their ripening, more squashes develop further out on the vines which seldom exceed ten or twelve feet in length. Orange Buttercup should be an excellent home garden variety and excell for the roadside market trade because of the bright attractive orange color of fruits.

Orange Bush Squash

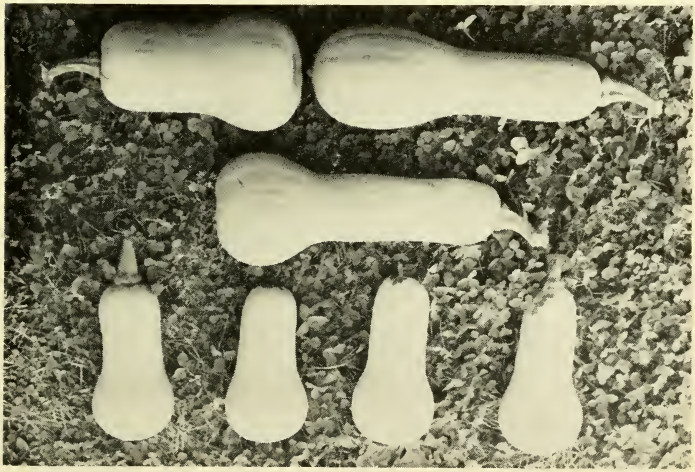
An extremely early, modified, bush-type squash, orange in color and similar to Orange Buttercup in quality, seems assured from a cross of an orange bush squash, Cheyenne #54125-1 from the United States Horticultural Station, Cheyenne, Wyoming, and New Hampshire Bush Buttercup. The second generation from this cross has been grown. At blossom time, the pistillate flowers of plants which mature green-colored fruits have light green ovaries and those which ripen orange fruits have light yellow ovaries. Only the yellow ovary plants were saved and self-pollinated in the field in 1956. Those squashes selected for seed after passing a cooking test had a bright orange skin and rich orange flesh of fine flavor and they were dry. The shapes were similar to Buttercup and the squash sizes varied from

This is an orange bush-type squash. The picture shows a plant with fruits set at the crown of the plant. This variety is not yet ready for introduction, however.

three to eleven pounds in weight. Several generations of self-pollinated plants must be grown to establish a desirable new variety that may be sufficiently early to mature even in the 100-day season of northern New Hampshire.

Baby Butternut Squash

Among the many varieties of winter squashes, Butternut is the only variety belonging to the species, *Cucurbita moschata*, which has become popular. This popularity has been in part due to the convenient shape and good table quality that has appealed to the consumers. To some people, the flavor becomes less desirable when the variety is eaten repeatedly. Growers have liked Butternut because the plants are naturally resistant to the destructive black pumpkin bug, though the productive vines are rather late in maturing their crop in much of New Hampshire. A weakness of the variety is that the fruits are markedly variable in shape. Both normal and undesirable slim and/or crookneck fruits are produced on the same plant.



The development of a new variety. Butternut (upper left) was crossed with Tsurukubi (upper right), a Japanese variety. At center is the first cross between them, and the four at the bottom are the result, the new Baby Butternut.

An oriental variety from Korea of somewhat similar type to the Butternut, but having a long neck, called Tsurukubi (Japanese for Heron's neck), was found to have dry, sweet, yellow flesh when cooked. Reciprocal crosses were made between Butternut and Tsurukubi. In the second generation, all plants that failed to blossom earlier than Butternut in the field were eliminated. Only those left were self-pollinated. After harvesting those selfed squashes of desirable size and shape, each squash was cooked and judged for table quality — a regular procedure carried on through all generations

until true breeding lines had been established. At least two generations were grown in the greenhouse during one winter season to hasten production of the new variety named Baby Butternut.

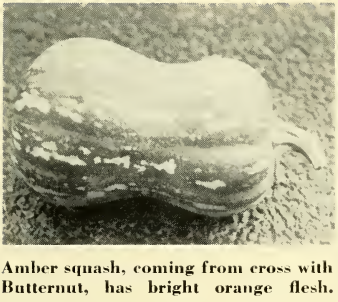
This is the harvest from just one plant of the Baby Butternut squash. This variety sets its fruit without pollination, thereby producing seedless squashes.

While superficially resembling Butternut, this new variety is smaller, weighing one and a half pounds and is of similar color and shape, but entirely free of crookneck fruits. Following harvest, Baby Butternut develops a waxy coating that aids in long storage. In the north, the squashes mature earlier than those of the Butternut variety. In the warm and long frost-free growing season of 1955, 34 squashes were harvested from a single plant of Baby Butternut and many widely-spaced plants had 22 or more fruits per plant. It is common to find a fruit at every node for some distance along the vine. Usually with most varieties such early female flowers drop and fail to set any fruit. The early female blossoms of Baby Butternut frequently set and develop very early, usable squashes that have few, if any, viable seeds. Squashes matured later in the season produce good seed.

Critical judges have rated Baby Butternut to be of high cooking quality, ranking it alongside Buttercup which is considered the standard for excellent table quality. Because of its dry good-flavored flesh, Baby Butternut lends itself nicely to baking. Within recent years, consumers have asked for squashes of a convenient individual size. When squashes of the new Baby Butternut variety are cut in halves lengthwise, the seeds scooped out and baked without peeling, two individual servings of high quality cooked squash are ready for table use. This convenience is not found in the large squashes that have to be cut up for marketing.

Amber Squash

This variety was developed simultaneously with the Baby Butternut, but from use of anothern Korean squash, Wase Kurokawa (Japanese for Early



Amber squash, coming from cross with Butternut, has bright orange flesh.

Sweet Chestnut), in crosses with Butternut. The selection from this cross has been for a family-sized squash larger than Butternut. According to a vote of visitors at an exhibition of various varieties and squashes of many sizes, shapes and color patterns, preference was for a squash of modified Butternut shape with an attractive mottled bicolor external pattern of green and tan. A selection meeting these qualifications and having dark orange rather sweet moist flesh has been called Amber. Its cooked quality resembles Butternut, but it is not equal to Baby Butternut. Hence, though some people who have grown and tested Amber like it very much, we have not encouraged its wide distribution because the Baby Butternut seems better. Amber is being used by other plant breeders in crosses to aid in development of new Butternut types free of the undesired crookneck fruits.

Bush Squash With Edible Seed

In Europe a pumpkin, *Cucurbita pepo*, which produces peel-less seeds, that is, those lacking the outer seed coats of normal seeds, is grown as an oil seed crop. Peeled pumpkin seeds are eaten as peanuts or nut meats in this country. As a food, these peel-less seeds are nutrionally equal to peanuts.

The individual-size winter squashes, such as Table Queen (Des Moines) and Delicata, belong to *C. pepo* and cross readily with both the summer squashes and pumpkins since they are all within the same species.

In 1939 a cross was made at Durham, New Hampshire, between Table Queen and a naked-seed pumpkin from Hungary. Dr. L. C. Curtis, while at the Connecticut Agricultural Experiment Station, also did some breeding work with the naked-seed pumpkins before 1948. The breeding project at New Hampshire did not progress rapidly until 1948, after seed of a naked-seed pumpkin, Olkurb, a variety that came from Margot Schubert, Henmarkt, Germany, had been furnished us through the courtesy of F. D. Hager, Needham, Massachusetts. Olkurb has vines that grow 30 feet in length and matures round oblate pumpkins over one foot in diameter. A cross of Olkurb was made with summer squashes: (1) an F_1-hybrid of UConn x Early Yellow Prolific, and (2) an F_1-hybrid of Early Yellow Prolific x Early Chinese, with the immediate objective of getting bush plants that bore squashes with naked seeds. Bush plant and naked seed are both recessive characteristics. Only one out of sixteen plants in the second generation from the cross of Olkurb x summer squash had this desired combination of bush plant and naked seed.

Following selection through several generations of self-pollination to insure lines breeding true for bush plant and naked seed, crosses of such purified lines were made with Burpee's Bush Table Queen and Delicata. Both varieties are high-quality table squashes, but have long vines, though

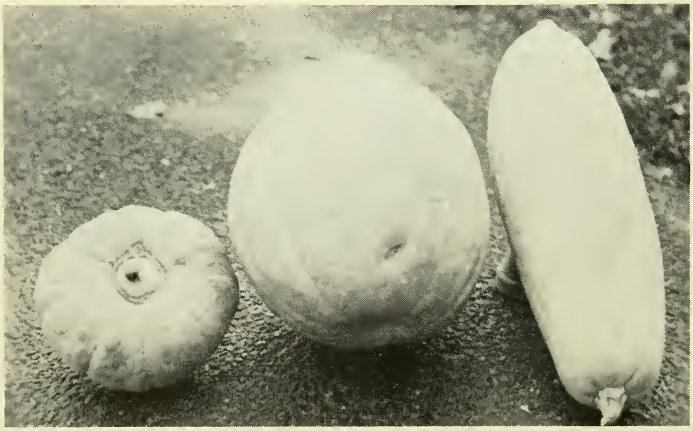
the vines of the Bush Table Queen seldom exceed ten feet. From these crosses, it was hoped that a variety having high-quality, naked-seed fruits somewhat similar to Table Queen or Delicata and borne on a bush plant could be obtained. Some selections approaching the desired ends were obtained, but they had only fair table quality. To improve their quality further, crosses were made again with Bush Table Queen and Delicata and a new series of selections was begun. At present, these selections have squashes that are equal to Table Queen in table quality, and have early productive plants that breed true for the naked seed character and bush plant. Following self-pollination of one or two more generations of plants, these promising selections should also be purified for size, shape, and color of fruits. Seemingly, a new variety of bush squash of the Table Queen type with edible seeds should appeal to home gardeners and eventually may be grown commercially as well.

The squashes, when cut into halves and baked without removing the edible seeds, have a rich nut-like flavor.

Large Orange Squash for Peeling

The demand by housewives for convenient products has led to the marketing of prepackaged squash peeled and cut ready to put in the kettle. Blue Hubbard, which has been a favorite variety in this region, is not well suited to this use. The green pigment that remains beneath the outer blue-gray skin when it is removed by peeling detracts from the appearance of orange flesh. A clear orange flesh is desired. Hence a variety with orange skin free of all green streaks of color would be an improved squash for peeling.

The same orange squash selected from the seed imported from Turkey, under the name Balkabagi and which was used in breeding the orange



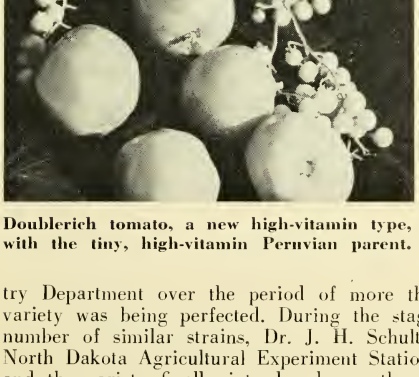
Start of squash-breeding project. Left, Balkabagi, a plant from Turkey. Right, Pink Banana, a commercial variety. In the center, their first cross.

Buttercup Squash, was crossed with Pink Banana, a variety used for processing in the western United States. The first generation gave a 20- to 25-pound orange squash of good quality with thick flesh. In fact, the F_1-hybrid might be worth growing as a commercial crop except for the necessary hand pollinations needed to produce the seeds for this first generation cross.

A second generation from this cross has been grown, and selection for a large, oval, smooth, orange squash with clear orange flesh that rates a high score in cooking tests has been continued through the fourth generation. It is a challenge to see how large a squash of excellent cooking quality can be obtained. Some fruits meeting the critical test for a cooked product and weighing 15 to 18 pounds have been saved for seed. Several more self-pollinated generations must be grown and it may be found necessary to cross the selected lines with other thick-fleshed large squashes before a new orange variety suitable for peeling and processing is ready for commercial use.

Doublerich Tomato

In Station Bulletin 380, a detailed account is given of the breeding work towards development of a commercial variety of tomato having a high vitamin C content.



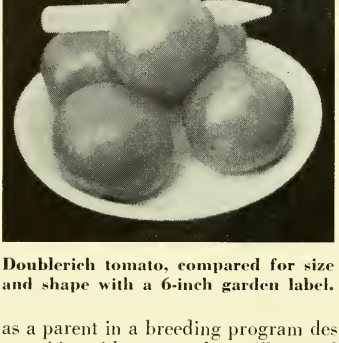
Doublerich tomato, a new high-vitamin type, with the tiny, high-vitamin Peruvian parent.

First, crosses were made between common tomatoes and P.I. 126946, *Lycopersicum peruvianum*. Next in order, selections from the hybrids having high ascorbic acid content and red-colored fruits were backcrossed twice to large size tomatoes. By continued selection for those plants having large fruits of a desirable type and high vitamin C, it was possible to establish the variety named Doublerich. Assays for ascorbic acid were made repeatedly by chemists* of the Agricultural and Biological Chemistry Department over the period of more than a decade while the new variety was being perfected. During the stage of final selections from a number of similar strains, Dr. J. H. Schultz and his co-workers at the North Dakota Agricultural Experiment Station participated in this project and the variety finally introduced was therefore a joint introduction of New Hampshire and North Dakota. Ordinary varieties of tomato commonly have from 15 to 25 milligrams of ascorbic acid per 100 grams of fresh fruit. Doublerich has had for three successive years by actual chemical

* Stanley R. Shimer, Dr. Helen Purinton, and Dr. Warren Averill each in turn assisted in this phase of the work.

determinations more than 50 milligrams of ascorbic acid for each 100-gram sample of fruit. This high content for tomatoes is the full equivalent of citrus fruits that can be grown only in subtropical regions.

This new tomato variety of high vitamin C content has an indeterminate or spreading vine. The very firm, red fruits ripen early, are smooth under New Hampshire conditions, and seem somewhat resistant to cracking of the fruits. They average three to four fruits per pound. The fruits have the character for uniform ripening. As a variety, Doublerich has popular appeal to those home gardeners who particularly appreciate the healthful properties of a tomato rich in vitamin C. When made into tomato juice or canned, the ascorbic acid is retained well. Some tomato juice assayed after having been stored for one year still had 50 milligrams per 100 grams of juice.



Doublerich tomato, compared for size and shape with a 6-inch garden label.

While Doublerich may not be generally adapted as a variety for successful culture in those areas specializing in canning crops, it can serve as a parent in a breeding program designed to originate new varieties of high ascorbic acid content that will meet fully the requirements for processing.

New Hampshire Red Pickling Tomato

Some tomato growers in southern New Hampshire produce green tomatoes for pickles. The variety Red Pear which has been used for this purpose has an indeterminate plant with fruits distributed at some distance along the stems. The cost of harvesting green tomatoes for pickles is comparatively high because of uneven maturity of fruits. For this reason, we decided to produce a red-pear tomato on a determinate vine which would be early and which would produce a large crop at one time so that the cost of production could be reduced.

The ordinary red-pear tomato was crossed with Fargo Yellow Pear, a variety produced some years ago at North Dakota Agricultural Experiment Station. The F_1-hybrids had a long vine and red fruits, and were productive and early. Seed from them gave many kinds of plants: some were determinate, some long, some with red fruit, some with yellow, some with uniform fruit color and some with fruits having green butts, some late, and some early. Selections were made from the early fruiting types with a fairly small, pear-shaped, red tomato. Since this is a comparatively simple breeding project, only two calendar years were required to complete it, during which time one generation was raised in the field each year and two in the greenhouse. The final result is New Hampshire Red Pickling Tomato from which one can pick a thousand tomatoes of pickling size per plant at one time. The variety has met with favor.

New Hampshire Surecrop Tomato

In certain years, the same organism, *Phytophora infestans*, that causes late blight of potatoes also produces rotting of tomato fruits rather late in the harvest season. Over a period of years, the Plant Pathologist at the New Hampshire Agricultural Experiment Station tested hundreds of varieties and strains of tomatoes for possible resistance to late blight. None proved resistant until seeds of a tomato were received from workers at the Rockefeller Foundation, Mexico City, by Dr. M. C. Richards in 1948. This tomato, designated as No. X907W, proved resistant both to artificial inoculations with late blight in the laboratory and under field conditions in a season when the disease was serious. However, the Mexican tomato, No. X907W, had fruits only the size of a marble and was of little value as a variety in itself. It would be classed as a cherry tomato, *Lycopersicum pimpinellifolium*.

It was decided to originate a commercial variety of tomato having the late blight resistance of the small cherry tomato from Mexico. Crosses were made readily between it and several standard varieties of the common tomato. The hybrids stood up against the ravages of late blight in the field when all other standard sorts were damaged severely.

The second generation was grown in the greenhouse and selections made for plants having large size fruits that were resistant to the disease. Dr. Avery Rich* maintained cultures of the late blight organism and sprayed

New Hampshire Surecrop tomato, a 1957 introduction. It is resistant to late blight prevalent in New Hampshire, and has some resistance to early blight.

* Plant Pathologist at the New Hampshire Agricultural Experiment Station from 1946 to the present.

the young tomato seedlings grown in flats in the greenhouse with late blight inoculum when the plants were only a few inches tall. After a few days incubation in a cool moist chamber, the resistant plants could be separated from those affected by disease. It was found that resistance to late blight was partially dominant. The F_1-hybrid plants were more resistant than the ordinary varieties. In the second generation, about one-quarter of the progeny were virtually immune, about one-half fairly resistant, and one-quarter of the progeny were decidely susceptible to the late blight. Only highly resistant plants were saved for further breeding work. Backcrosses were made to a variety received from Argentina called Mikado which in itself seemed less susceptible to various tomato diseases than most varieties, though it had potato leaf and large, rough, fasciated fruits.

Promising lines carrying good resistance to late blight were selected from the backcross progenies, but no line having all the necessary horticultural characteristics for a commercial variety was realized. Another cross was made to the early-maturing New Hampshire Victor, and productive blight resistant selections of a good size and quality were recovered in the second generation. After being purified, a true-breeding line resistant at least to those races of late blight prevalent in New England has been named New Hampshire Surecrop. This new early variety has a determinate plant productive of uniform-colored red fruits rather similar to those of Victor, but in contrast New Hampshire Surecrop has tolerated late blight under field conditions in New Hampshire. It is also somewhat resistant to early blight, *Alternaria*, much more so than the early-maturing determinate varieties of tomatoes observed at Durham, New Hampshire. Since many varieties of tomatoes are adapted only to certain localities, New Hampshire Surecrop may not be fully acceptable over the wide areas devoted to tomato culture. This variety should prove valuable as breeding material for plant breeders. Seeds have been sent already to them in widely separated places throughout the world.

Irradiation to Induce Variations in Tomatoes

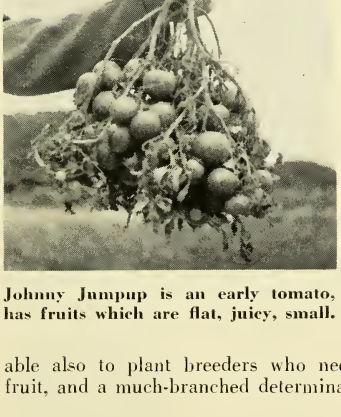
Early blight of tomato, *Alternaria*, in many years is a disease that seriously limits the yield of ripe fruits, particularly so for early-maturing determinate varieties. No source of complete resistance to the disease has been found yet among the early determinate tomatoes observed to date. Disease-resistant varieties of cereal crops have been reported, however, following exposure of seeds and plants within radiation fields at the Brookhaven National Laboratory for studies with atomic energy.

Seeds of the Chatham, an early determinate variety of tomato, were sent to the National Laboratory, Brookhaven, Long Island, for treatment. Both X-ray and thermalneutron radiations were given the seeds. Some seeds received ten thousand, twenty thousand, and thirty thousand roentgens of X-rays, respectively. Other lots were exposed to thermalneutrons for 15, 20, and 25 hours respectively. Following these treatments, the seeds were returned to Durham, New Hampshire, for starting plants that were grown in the open field in 1956.

Germination vigor of the seeds treated with X-rays varied between plants from very weak to strong. However, by the end of the growing season, there was little if any apparent differences among these plants.

On the other hand, seeds treated with thermalneutrons produced plants that seemed rather uniform within the treatments at the time they were planted in the field. There were noticeable differences in vigor between the different treatments. Plants from seeds having the lowest rate of exposure (15 hours) differed little from untreated plants. Those plants from seeds treated for 20 hours were reduced somewhat in their vigor, while those from seeds exposed to 25 hours of the thermalneutrons were much smaller than the untreated plants. As the growing season progressed, many sterile plants or those having a branch of the plant unfruitful were noted. Whether there might have been any effect on disease resistance could not be learned in this one growing season. This experiment is rather highly speculative, but might eventually make available some useful character for continued plant breeding with the tomato.

Johnny Jumpup Tomato



Johnny Jumpup is an early tomato, has fruits which are flat, juicy, small.

Extreme earliness is always important in tomatoes for the north. A selection made at Colebrook, New Hampshire*, is outstanding in this respect. Bison, Victor, and Farthest North are involved in its ancestry. This selection has been distributed for trial as BV #5. This tomato makes a compact plant, two feet or less in diameter that ripens its entire crop from seed in 100 days. The oblate red fruits have many locules and run six to the pound. While not a commercial tomato, it is an interesting home garden variety, useful for juice and salads. Johnny Jumpup tomato ripens its crops so early that seed can be sown direct in the field in southern New Hampshire and still ripen its full crop. It should be valuable also to plant breeders who need extreme earliness, a many loculed fruit, and a much-branched determinate plant in a parent.

Market Midget Watermelon

The New Hampshire Midget watermelon, previously introduced, has met with such wide acceptance the world around, that it would seem desirable to correct one of its defects, the brittleness of the rind. When the fruits are piled in the store or handled roughly, they are apt to break. New Hampshire Midget, while high in quality, has a short market life. For this reason a cross was made between New Hampshire Midget and Winter Queen, a variety with tough rind and which can be stored for several weeks. From

* Henry Clapp was in charge of the northern New Hampshire plots at the time.

this cross, following our usual procedure of growing one crop in the field and two self-pollinated crops indoors, the purification of a new desirable variety has been rapid. A simple test for toughness of rind is to cut away from the flesh a small strip of rind and then bend it between the fingers. Those fruits having a rind which may be bent nearly into a circle without breaking were selected as being most desirable.

Selections also have been made for melons with bright red flesh and relatively few black seeds. The result is a new midget variety with light green skin color which matures early, is productive, very sweet, and which has kept for a month in the field after frost in good condition. This convenient icebox or midget watermelon should be suitable for shipment to distant markets.

Orange-Rind Watermelons

New Hampshire Midget watermelon was developed primarily for home garden use. Since its introduction, it has been grown commercially also over wide areas. This melon of small convenient size is so early that some gardeners, not realizing that the melons could be ripe in 65 to 70 days after direct planting of the seed in the open field, have allowed the melons to spoil before they thought them ready for use. A frequent complaint has been that the grower could not easily tell when his watermelons were ripe. Mr. M. Hardin, Geary, Oklahoma, sent to us for trial a variety called Pumpkin Rind. This interesting watermelon has a rind green in color up until the melon ripens at which time it turns orange-yellow. The flesh was pink in color and of only fair edible quality. Seeds were nearly white with only a small spot of dark color. A cross was made with New Hampshire Midget to develop a small size high quality melon that would turn orange when ripe, this color change to serve as a criterion for telling when the fruit was ready for harvest.

This new midget watermelon turns orange when ripe. It is not ready for introduction yet, but it should be popular because of its built-in ripeness indicator.

The first-generation melons were all green rind and the recessive pumpkin-rind character did not appear until the second generation. In the second generation, yellow-rind melons of various sizes were secured. Those having the desired small size and reasonably good quality flesh of red color with dark colored seeds were selected and their seeds were saved for planting in the greenhouse. These plants were self-pollinated and gave sufficient seed for planting about one acre of golden-rind watermelons in the field in 1956. Of the hundreds of melons ripened in the field, only three were judged to have sufficiently high quality to merit being grown in the greenhouse again. Progenies grown from seeds of these three melons have been backcrossed to high-quality, normal, green-rind melons to aid in improving the quality of the orange-rind selections. It seems possible to produce a watermelon variety having the size, quality, and productivity of the New Hampshire Midget and which will have an orange color of skin when ripe.